Excluding and Rust Inhibiting Properties of Paint Pigments for the Protection of Steel and Iron

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PRESENTED BEFORE THE FORTIETH ANNUAL CONVENTION OF THE MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION OF THE UNITED STATES & CANADA

NIAGARA FALLS, NEW YORK, S BER 14th, 1909

DIAGRAM

PAINT TEST-STEEL FENCE
ATLANTIC CITY, N. J

ERECTED, PAINTED AND EXPOSED.
OCT 16, NOV 18, 1908.
LOCATION-DOVER AND VENTNOR AVES.

H. A. GARDNER
DIRECTOR OF TEST
SCIENTIFIC SECTION
PAINT MANUFACTURERS ASSOCIATION

FENCE Nº 1

FRONT	BACK
I 1	I 1
I 2	I 2
I 3	I 3
I 4	I 4
I 5	I 5
I 6	I 6
I 7	I 7
I 9	I 9
I 10	I 10
I 12	I 12
I 14	I 14
I 15	I 15
I 16	I 16
I 17	I 17
I 19	I 19
I 20	I 20
I 21	I 21
I 24	I 24
I 27	I 27
I 28	I 28
I 29	I 29
I 30	I 30
I 31	I 31
I 32	I 32
I 33	I 33
I 34	I 34
I 36	I 36
I 39	I 39
I 40	I 40
I 41	I 41
I 44	I 44
I 45	I 45
I 48	I 48
I 49	I 49
I 51	I 51
I B 111	I C 111
I B 222	I C 222
I C 333	I B 333
I C 444	I B 444
I C 555	I B 555
I C 666	I B 666
I C 777	I B 777
I C 888	I B 888
I C 2000	I B 2000
I C 3000	I B 3000
I C 4000	I B 4000
II B 100	II C 5555 2 Coats
II C 100	II B 5555 3 Coats
II B 90	II B 6666
II C 90	II C 6666
5555 Over Red Lead	I Steel with Scale No Paint
B 1000 1 coat	II C 7777
*1 Plate Boiled Linseed oil 3 Coats	
*6 Steel Pickeled	

FENCE Nº 2

FRONT	BACK
II 1	II 1
II 2	II 2
II 3	II 3
II 4	II 4
II 5	II 5
II 6	II 6
II 7	II 7
II 9	II 9
II 10	II 10
II 12	II 12
II 14	II 14
II 15	II 15
II 16	II 16
II 17	II 17
II 19	II 19
II 20	II 20
II 21	II 21
II 24	II 24
II 27	II 27
II 28	II 28
II 29	II 29
II 30	II 30
II 31	II 31
II 32	II 32
II 33	II 33
II 34	II 34
II 36	II 36
II 39	II 39
II 40	II 40
II 41	II 41
II 44	II 44
II 45	II 45
II 48	II 48
II 49	II 49
II 51	II 51
II C 111	II B 111
II B 222	II C 222
II C 333	II B 333
II C 444	II B 444
II C 555	II B 555
II C 666	II B 666
II C 777	II B 777
II B 888	II B 888
II C 2000	II B 2000
II C 3000	II B 3000
II C 4000	II B 4000
II B 4444 2Coats	I B 3333
II C 4444 2Coats	III C 3333
II B 1000X	IV B 3333
II C 1000X	V B 3333
II Steel Pickeled & Exposed No Paint	II Black Plate No Paint
B 1000 Chrome Resinate 2Coats	
1 Coat Shellac with 1/10% Cr O.	
*6 Steel Pickeled	

FENCE Nº 3

FRONT	BACK
III 1	III 1
III 2	III 2
III 3	III 3
III 4	4
III 5	III 5
III 6	III 6
III 7	III 7
III 9	III 9
III 10	III 10
III 12	III 12
III 14	III 14
III 15	III 15
III 16	III 16
III 17	III 17
III 19	III 19
III 20	III 20
III 21	III 21
III 24	III 24
III 27	III 27
III 28	III 28
III 29	III 29
III 30	III 30
III 31	III 31
III 32	III 32
III 33	III 33
III 34	III 34
III 36	III 36
III 39	III 39
III 40	III 40
III 41	III 41
III 44	III 44
III 45	III 45
III 48	III 48
III 49	III 49
III 51	III 51
III B 111	III C 111
III B 222	III C 222
III C 333	III B 333
III C 444	III B 444
III C 555	III B 555
III C 666	III B 666
III C 777	III C 777
III C 888	III B 888
III C 2000	III B 2000
III C 3000	III B 3000
III C 4000	I B 7777
III C 4000	I C 1111
I B 2222	IV B 1111
II C 2222	V B 1111
IV B 2222	IV Steel Without Paint
V B 2222	V Steel without Paint
III Pickeled and Exposed	VI Steel Without Paint
Linseed Oil	
*6 Steel Pickeled	

Nº 1 Dutch Process White Lead
Nº 2 Quick Process White Lead
Nº 3 Zinc Oxide
Nº 4 Sublimed White Lead
Nº 5 Sublimed Blue Lead
Nº 6 Lithopone
Nº 7 Zinc Lead White

Nº 9 Orange Mineral American
Nº 10 Red Lead
Nº 12 Bright Red Oxide (62 a)
Nº 14 Venetian Red
Nº 15 Princes Metallic Brown
Nº 16 Natural Graphite
Nº 17 Acheson Graphite

Nº 19 Lamp Black
Nº 20 Willow Charcoal
Nº 21 Gas Carbon Black
Nº 24 French Yellow Ochre
Nº 27 Barytes Natural
Nº 28 Barytes Precipitated
Nº 29 Calc. Carb. (Whiting)

Nº 30 Calc. Carb. Precipitated
Nº 31 Calcium Sulphate (Gypsum)
Nº 32 China Clay (Kaolin)
Nº 33 Asbestine (Silicate Magnesium)
Nº 34 American Vermilion (Chrome Scarlet)
Nº 36 Med. Chrome Yellow
Nº 39 Zinc Chromate

Nº 40 Zinc & Barium Chromate
Nº 41 Chrome Green (Blue Tone)
Nº 44 Prussian Blue (Stimulative)
Nº 45 Inhibitive Prussian Blue
Nº 48 Ultramarine Blue
Nº 49 Zinc & Lead Chromate
Nº 51 Magnetic Black Oxide

Nº 90 Straight Lamp Black Paint with Turps & Dryer
Nº 100 " " Carbon " " " " " "
Nº 1000 Chrome Resinate in oil
Nº 2000 1 Coat Zinc Chromate 1 Coat Excluder
Nº 3000 1 " Lead " " 1 " "
Nº 4000 1 " Red Lead 1 " "
Nº 111 Brown. Inhibitive Paints

Nº 222 Black Inhibitive Paints
Nº 333 White " "
Nº 444 Green " "
Nº 555 Black Stimulative Paints
Nº 666 Brown " "
Nº 777 White " "
Nº 888 Green " "

Nº 1111 Green Special "G" Formula
Nº 2222 Red " " "
Nº 3333 Black " " "
Nº 4444 A. Excluder Paint
Nº 5555 Coal Tar Paint
Nº 6666 Special Paint
Nº 7777 Special Gl Paint

Analysis of Steel in Plates

	Nº 1 Fence	Nº 2 Fence	Nº 3 Fence	Nº 4 Fence	Nº 5 Fence	Nº 6 Fence
	Bessemer Steel	S. Open Hearth	Pure Iron	Special Bessemer Steel	Special Charcoal Iron	Spellerized Steel
Carbon	.08	.16	.03			
Manganese	.35	.44	Mere Trace			
Phosphorous	.08	.02	.005			
Sulphur	.05	.024	.024			

Roman Numerals = Class of Steel
Arabic Numerals = Number of Paint

"B" = Black Plates with scale
"C" = Pickeled Plates

Plates pickeled in Sulphuric Acid were used throughout on the pigments up to #51, using a definate spreading rate of 900 Sq. Ft. per gallon in applying the paint. Above this number, cleaned plates were used with the definate spreading rate as above, and black plates were used without any spreading rate.

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PREFACE

The master painter will find herein a statement of the results obtained in the most recent study into the corrosion of iron and the development of protective coatings for the protection of iron. It is sincerely hoped that this pamphlet will be of considerable value to him in his work.

HENRY A. GARDNER

CHAPTER I

Results in Recent Testing of Pigments

Study of Corrosion Necessary when Designing Protective Coatings

The many theories, regarding the causes of the corrosion of iron, advanced during the last decade, have stimulated a great amount of original research on this subject by various investigators. In the course of these investigations the subject of protective coatings for iron and steel naturally has been brought into prominence and is receiving a considerable amount of attention.

The study of protective coatings for iron and steel, conversely, has led many interested paint manufacturers and users of painting materials to make a closer study of the causes of corrosion in order that they may know how to make and use better paints for protecting steel. In so doing, they have discovered that the two subjects are intimately connected and vitally important to each other.

No attempt will be made to cover the subject of the painting of steel cars or locomotives, or to outline any method for so doing, but the object of this paper is to bring before you as Master Painters, entirely new light upon the subject of pigments and their properties and values, so that you may, yourselves, select with good judgment the proper pigments to use for various purposes. If, in the past, you have been using pigments which are poisonous to

steel and which cause active corrosion, you should know it, and if, in the future, you can select pigments which are antiseptics and preventives of rust, you should use them.

A series of very interesting and instructive researches into the nature of the various paint pigments used in the painting of iron and steel, as a determining factor in the corrosion of iron, were recently made, and, as a result of these investigations, it has been possible for certain laws to be formulated, regarding the value of these pigments. Through a previous bulletin of the Scientific Section, namely, the "Preliminary Report on Steel Test Fences," the paint trade at large was informed of these investigations, but the results were withheld tentatively for the reason that the Scientific Section had no desire to publish any information, no matter how reliable the source from which it was obtained, without having absolute verification of results.

Results of Recent Tests on Nature of Pigments

The tests referred to were made upon fifty pigments largely used in the fabrication of paints, in order to determine which possess stimulative, which inert, and which inhibitive characteristics when in contact with steel in the presence of water. Bulletin No. 35, by Allerton S. Cushman, one of the foremost investigators in this line of research, was recently issued by the Office of Public Roads of the United States Department of Agriculture, and the results of these tests were published therein.

The paint manufacturer has drawn attention to the fact that some of these pigments which, in water, cause marked corrosion, when painted out in oil, give steel and iron immunity from corrosion for some period. The excluding value of such pigments may account for their protection for a certain time. However, when the film of oil has been destroyed, the pigment is subject to the moisture which acts to stimulate corrosion.

The following table is printed in Bulletin No. 35, by Allerton S. Cushman, of the United States Department of Agriculture:

BASIC CLASSIFICATION OF PIGMENTS

INHIBITORS	INDETERMINATES	STIMULATORS
Zinc Lead Chromate	White Lead (quick process, Basic Carbonate	Lamp Black
Zinc Oxide	Sublimed Lead (Basic Sulphate)	Precipitated Barium Sulphate (Blanc Fixe)
Zinc Chromate	Sublimed Blue Lead	Ocher
Zinc and Barium Chromate	Lithopone	Bright Red Oxide
Zinc Lead White	Orange Mineral (American)	Carbon Black
Prussian Blue (Inhibitive)	Red Lead	Graphite No. 2
Chrome Green (Blue tone)	Litharge	Barium Sulphate (Barytes)
White Lead (Dutch process)	Venetian Red	Graphite No. 1
Ultramarine Blue	Prince's Metallic Brown	Chinese Blue (Stimulative Prussian)
Willow Charcoal	Calcium Carbonate (Whiting)	
	Calcium Carbonate (precipitated)	
	Calcium Sulphate	
	China Clay	
	Asbestine	
	American Vermilion	
	Medium Chrome Yellow	

The following table gives the results obtained by the different investigators in determining by an accelerated test the relation of the various paint pigments in their effect on iron and steel in the presence of water. The losses

LOSS OF STEEL IN GRAMS IN TESTS CARRIED OUT ON PIGMENTS TO ASCERTAIN THEIR VALUE AS RUST INHIBITORS

	Pigment	Gardner No. 1 20 days	Cushman Nos. 1 & 2 10 days	Walker P. H. No. 2 7½ days	Cushman No. 2 10 days	Walker W. H. No. 1	Aver'ge
1	Zinc Chromate	.0050	.0300	.0094	.0130	.0396	.0194
2	Zinc and Barium Chromate	.0153	.0468	.0034	.0140	.0351	.0229
3	Zinc and Lead Chromate	.0094	.0277	.0153	.0085	.0620	.0246
4	Zinc Oxide	.1524	.0296	.1002	.0085	.0504	.0682
5	Zinc Lead White	.0842	.1712	.0515	.0856	.0456	.0876
6	Barium Chromate	.2333	.0101	.0429	.0094	.1932	.0978
7	Ultramarine Blue	.0247	.3185	.0137	.1865	.0496	.1186
8	Chrome Green (blue tone)	.0860	.2269	.0548	.1240	.2346	.1453
9	Prussian Blue Inhibitive	.1438	.2267	.0448	.1130	.2671	.1591
10	Lithopone	.0160	.3791	.1274	.1792	. . .	.1754
11	Willow Charcoal	.1694	.2795	.1439	.1362	.2110	.1880
12	Litharge	.4325	.1932	.0309	.1584	. . .	.2038
13	Dutch Process White Lead	.2040	.2895	.1781	.1150	.2743	.2122
14	Quick Process White Lead	.2120	.3352	.1288	.1848	.2274	.2176
15	Calcium Sulphate	.3966	.2143	.1759	.1597	.2174	.2328
16	Prince's Metallic Brown	.3774	.2620	.1983	.1408	.1974	.2352
17	Orange Mineral French	.3950	.2724	.1495	.1467	.2526	.2432
18	Calcium Carbonate (Whiting)	.3828	.3620	.1384	.2380	.1208	.2484
19	Sublimed Blue Lead	.3177	.3425	.1001	.2365	. . .	.2492
20	Lemon Chrome Yellow	.2767	.4067	.1365	.1972	. . .	.2543
21	Orange Chrome Yellow	.2826	.4203	.1700	.1907	.2150	.2557
22	Medium Chrome Yellow	.4090	.3767	.1319	.1763	.2288	.2645
23	Chrome Green (yellow)	.3265	.3670	.1348	.1453	.3521	.2651
24	Venetian Red	.2682	.4756	.1955	.2375	.1564	.2666
25	Bone Black	.3392	.3245	.0921	.1413	.4401	.2674
26	Asbestine	.2394	.4025	.1748	.2240	.3405	.2762
27	Keystone Filler	.3560	.4651	.1366	.3349	.1481	.2881
28	Orange Mineral American	.4416	.4336	.1719	.2065	.2315	.2970
29	Umber	.1365	.5961	.1498	.3817	.2403	.3009
30	China Clay	.3493	.4770	.1248	.2445	.3212	.3034
31	Calcium Carbonate Precipitated	.3574	.4910	.1828	.2625	.2616	.3111
32	Red Lead	.3112	.3555	.1495	.1717	.5707	.3117
33	Prussian Blue Neutral	.3584	.4463	.1218	.2415	.4173	.3171
34	Indian Red	.3546	.3739	.2617	.1905	.4334	.3228
35	American Vermilion	.4328	.4147	.2612	.1877	.3387	.3270
36	Sublimed Lead	.4176	.5856	.0982	.2372	.3116	.3300
37	Sienna	.2876	.5432	.2949	.3085	.4462	.3761
38	Naples Yellow	.6482	.4800	.1512	.2347	.3846	.3797
39	Prussian Blue Stimulative	.5113	.4559	.2055	.2195	.5202	.3825
40	Mineral Black	.3050	.8018	.2017	.3529	.3353	.3993
41	Barytes	.4454	.5883	.2547	.3841	.5636	.4472
42	Natural Graphite	.4342	.5437	.2606	.3173	.7165	.4545
43	Bright Red Oxide	.3878	.7896	.2920	.3707	.4429	.4566
44	Acheson Graphite	.5262	.6337	.3723	.2789	.5095	.4641
45	Ochre	.4022	.8408	.2119	.4315	. . .	.4716
46	Carbonith White	.2655	. . .	. . .	. . .	.7152	.4904
47	Carbon Black	.5003	.6955	.4069	.3751	.5716	.5099
48	Precipitated Blanc Fixe	.5247	.8806	.3132	.5085	.5064	.5467
49	Lamp Black	.7180	1.3098	.2838	.7096	.6257	.7294

in weight measure the amount of corrosion. The most inhibitive head the list and the most stimulative are at the bottom.

CHAPTER II

Pigments in Aqueous vs. Oil Medium

Objections Offered to These Tests

Some objections were made by chemists to the tests of the different pigments in water medium, on the ground that pigments which might stimulate corrosion in the presence of water would not do so in oil medium. Claims were made that oil acts as an envelope for the pigment particles, and being a non-conductor of electricity, prevents any electrolytic action taking place on the steel plates upon which they are painted out.

Tests Made with Pigments in Oil

These objections suggested some rather interesting experiments. Upon several slides of glass, such as are used for mounting microscopic specimens, were painted out various pigments ground in oil. Upon these plates of glass thus painted and after they were properly dried, were firmly secured small strips of copper at either end. To the ends of the strips of copper were attached the wires of an ordinary dry cell. Into this circuit was placed a very delicate galvanometer. It was found that absolutely no current flowed through the paint film, and the galvanometer needle remained in its original position, at zero.

Results Confirm Previous Work

The glass slides were then removed from the apparatus and immersed in water for a while, during which time they were penetrat-

ed by the water to a certain extent, thus duplicating in a quick way the action of rainstorms upon paint coatings over an extended period. The slides were removed from the water and, after being carefully wiped off, were again connected up in the apparatus.

Conductivity of Moist Films by Stimulative Pigments

Non-Conductivity of Moist Films of Inhibitive Pigments

It was then found that certain pigments which are good conductors of electricity permitted the current to flow, and the galvanometer needle was deflected to quite an extent. On the other hand, in the case of pigments which are absolutely non-conductors of electricity, there was no movement of the needle. As would be expected, those pigments which caused deflection of the galvanometer, such as the carbonaceous group, were in the active stimulative class, while those which prevented the deflection of the galvanometer needle were in the inhibitive class. These results confirm Dr. Cushman's results regarding the nature of such pigments. Corrosion in structural steel in situ appears to be dependent largely upon what Dr. Thompson, in commenting on the work of Cushman, Walker and others, has aptly designated "auto-electrolysis"—that is, electrolysis due to currents set up between areas having different potentials in the material itself. These currents require the presence of an electrolyte to serve as a conductor and thus complete the electrical circuit. It thus appears probable that a paint film which, when moistened, becomes a good conductor of electricity, may serve as an active aid to corrosion through this physical quality alone.

CHAPTER III

Results of Inspection of Steel Test Fences

As explained in the "Preliminary Report on Steel Test Fences," in order to make a practical field test of the value of various pigments, it was decided by the Paint Manufacturers' Association to erect steel test fences at Atlantic City, upon which to paint out in oil medium all the pigments which previously had been tested out by so many investigators in aqueous medium.

Steel Test Fences for Practical Field Test of Value of Various Pigments

The work was carried out with the greatest care by the Scientific Section and was under the supervision of Committee E, on Preservative Coatings, and Committee U, on Iron and Steel, of the American Society for Testing Materials. The Master Painters' Association of Pennsylvania was also represented in the work.

In the front of this book will be found a chart of the fences, showing the placement of every panel and giving the formula of the paint applied thereon. This chart will be of considerable value to anyone desirous of making a personal investigation of the fence.

A recent inspection of the fences indicated that it was too early to make a report, but a few observations recently made, may not be out of place at this time.

It was found that the white lead and zinc oxide pigments appeared to have thus far given excellent protection to the steel and iron upon which they were painted. The pure white lead, however, has shown tendency to chalk, while in some cases the zinc oxide has shown tendency toward checking. The red iron oxides applied to the steel plates seemed to be in good condition, with the possible exception of Venetian red on which there seemed to be a very slight exudation or leaching out of the calcium sulphate contained in this pigment.

Condition of White Lead, Zinc Oxide, Oxide of Iron Paints

An examination of the graphite, lamp black and carbon black films showed that it was too early to report on their value. These films are still intact and the color prevents close examination of the underlying surface. However, it was observed that wherever the plates, which were painted with these pigments, had been abraded to the least degree, very active corrosion had started, and appeared to be spreading underneath the paint coating.

Condition of Carbonaceous Paints

The plates painted with red lead were in excellent condition, as were also those painted with zinc chromate and zinc-and-barium chromate. In the case of the plates painted with zinc chromate, several abrasions made at the time of erecting the fence disclosed the clean steel plate which had suffered practically no corrosion. This, presumably, is due to the fact that zinc chromate being slightly soluble had kept the abraded places in a passive state and prevented any rust forming thereon. The

Inhibitive Pigments Standing Well

Value of Chromium Pigments

plates painted with chromium resinate seem to be in excellent condition, and the high efficiency of this pigment as a water excluder may prove it to be a valuable ingredient of a protective paint coating.

Prime Coaters

The plates, which were primed with various inhibitive pigments and topped with the same second-coater, have not shown as yet any definite results which would indicate which pigment to use as a prime coating material.

Defects Observed on Coal Tar Paints

The plates, which were coated with red lead and second-coated with bitumen and coal tar paints disclosed a most marked alligatoring of the top coats, through which the red lead used as a prime coater could be distinctly seen. Unequal expansion of the two coats is probably responsible for this fault.

Marked Rust Acceleration on Plates Coated with Gypsum

Those plates painted with calcium sulphate (gypsum) showed the most marked corrosion, the plates showing a brown coating of oxide of iron working itself completely under the coating.

Natural and Artificial Barium Sulfate and Calcium Carbonate

It was noticed that calcium carbonate and barium sulphate, both in the precipitated form, as applied to the steel panels, exhibited considerable chalking, while calcium carbonate and barium sulphate in their natural state, as whiting and barytes respectively, were standing up much better, no chalking being evident. The precipitated forms of calcium carbonate and barium sulphate gave the greatest hiding power, being quite opaque, while the natural forms, were very transparent.

Rate of Corrosion on Various Unpainted Plates

The several samples of steel which were exposed unpainted after having been pickled showed varied degrees of corrosion, but it is too early as yet to report upon these plates. However, those plates which were exposed unpainted, but having the mill scale showed more rapid corrosion and more pitting than those plates not having the mill scale; in fact some of these plates having the mill scale corroded in certain spots in an extremely rapid way, leaving certain areas with the mill scale unacted upon. The mill scale in this case would act as a surface upon which the hydrogen evolved during the electrolytic action which accompanies the process of corrosion could be catalyzed to form water, thus allowing the corrosion to proceed very rapidly. This bears out the statement of Dr. W. H. Walker, Prof. of Industrial Chemistry at the Mass. Inst. of Technology, regarding the function of oxygen in the corrosion of iron and the action of mill scale as a depolarizing surface.*

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*This recalls some recent work done by Dr. Walker in which he finds linseed oil to be, under certain conditions, an accelerator of corrosion. He found that when a steel or iron surface painted with linseed oil became abraded in any particular spot, corrosion would proceed more rapidly in the presence of the coating of oil than without the coating. This he ascribes to the fact that the hydrogen, which is evolved during the corrosion is removed immediately by the linseed oil, which (being an unsaturated hydrocarbon) has an enormous power of absorbing the hydrogen and acts very much in the same way as mill scale in destroying the "electrolytic double layer," so-called. In the event, however, of the linseed oil containing different pigments there is a marked difference in the ability of the linseed oil to remove the hydrogen with sufficient rapidity to accelerate corrosion.

Wherever an abrasion appeared upon the paint coatings of the various panels, different results were noted. In the case of panels which were painted with certain stimulative materials, abrasions showed progressive corrosion had proceeded and pitting was evident, while in the case of panels painted with high power inhibitive materials, the steel was in very good condition.

Scratching Plates to Observe Action of Oil Coatings

In order to give this new development in the study of the corrosion of iron a practical field test, each plate on the steel test fences has recently been scratched at the lower right hand corner, using the same instrument in each case. The painted surfaces being thus abraded, the progress of the corrosion will be carefully watched and most interesting data may be recorded later on as regards the value of each pigment in linseed oil in checking any accelerative action which may be exerted by the linseed oil.

CHAPTER IV

Excluding and Water-Resisting Properties of Paints

Besides considering the pigments as stimulators and inhibitors, a most careful study has been made by the Scientific Section as to the value of various pigments as excluders or moisture resisters.

Excluders and Water Shedders

An excluding paint is one that has the property of excluding and preventing the admission of moisture to the steel, thus depriving the steel of the moisture which is essential to corrosion. A water-shedding paint is one which has the property, because of certain physical characteristics, of shedding water, and plates painted with such paints often appear dry immediately after a rain storm. Pigments greasy and unctuous in nature make good water-shedding paints. They may or may not have excluding values.

Properties of Excluding Paints

The excluding properties of a paint coating are largely dependent upon the composition of the vehicle. It has been proved beyond doubt that a vehicle the interstices of which are filled up with fused gum is superior in its water excluding properties. Some excluders do not have the property of moisture shedding, and observations have been made of

several plates painted with natural excluding materials which did not shed water, but which were the most perfect water excluders. Ordinarily linseed oil, when painted out and dry, is neither an excluder nor a moisture resister, as the tackiness of the film will show after a rain storm. A peculiar blistering appearance is also shown on the surface, showing where rain drops have acted upon the vehicle and penetrated through, leaving the coating soft and pliable and sometimes raising many blisters thereon.

Water Shedders Not Always Permanent

Considerable value has been attached to certain protective coatings whose only real virtue was that of being able to resist the action of rain and water, but which would ultimately break down in a very rapid way, allowing deep penetration by the water. The water shedding pigments which we have mentioned as being greasy in nature or unctuous, serve sometimes, when made into paints, as good protective coatings for a time, but sooner or later fail completely in their object.

How Moisture Goes Through a Paint Film

It has often been asked, in what manner does water penetrate a paint coating? When the coating is comparatively new and the linoxyn intact, the water goes through probably in two ways: either by forming a solid solution with the linoxyn coating itself and becoming a part of the paint, or by diffusing through the linoxyn, which is really a porous membrane.

Thus it would appear that the use of dif-

ferent pigments would produce more or less permeable films, according to the proportion of space filled up in the vehicle.

Properties of Different Pigments in Retarding Moisture Penetration

That certain pigments do have the power of preventing to a certain extent more than others the admission of water through a paint coating, the following series of experiments seem to prove.

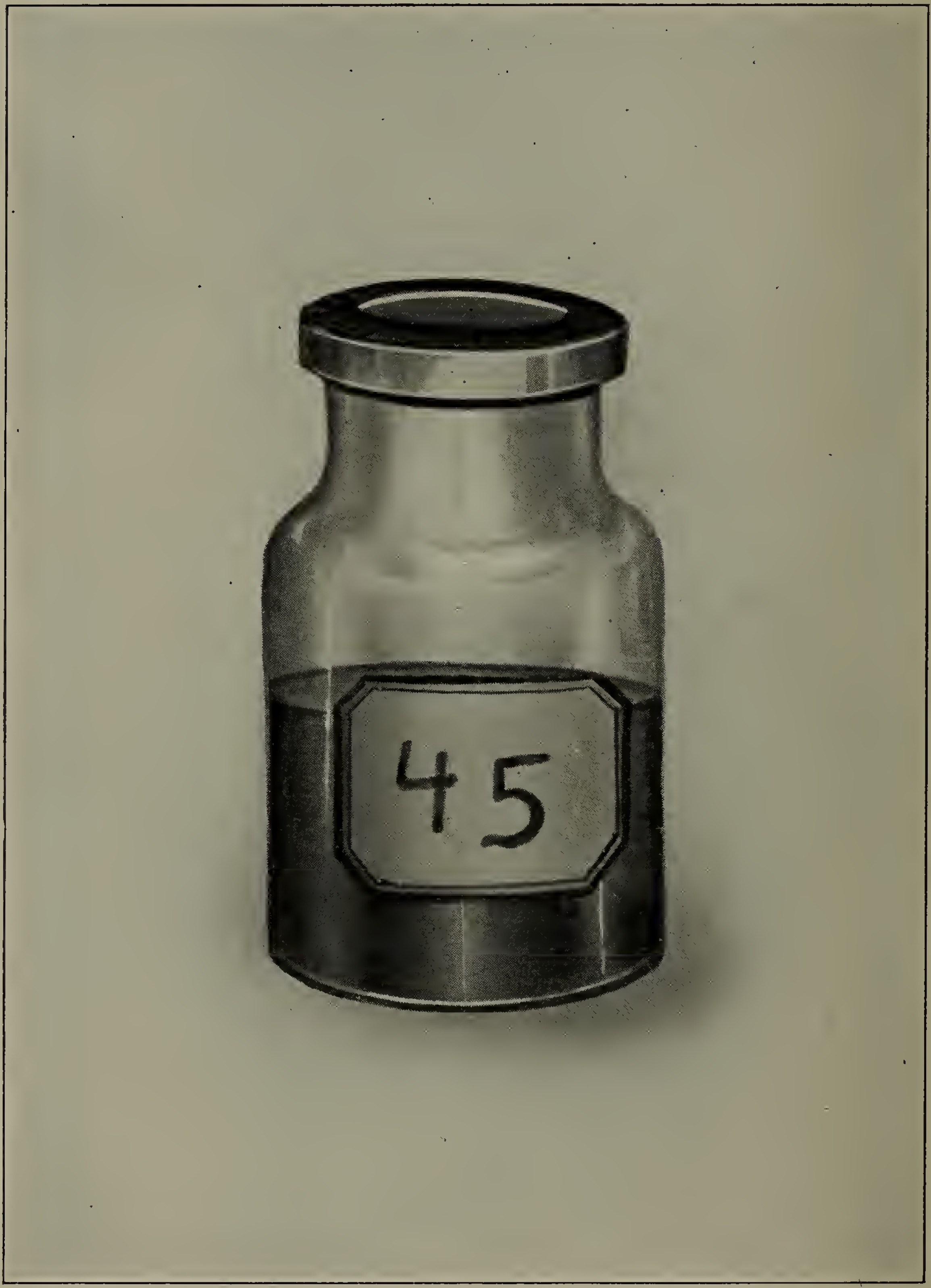
Films made of Paints Used on Steel Fences

A series of paint films were made from many of the pigments which were used in painting the Atlantic City test fence. These paints contained the pigment ground in two-thirds raw and one-third boiled oil, without drier, and the films were painted out in three-coat work, allowing ample time between each coat for proper drying. No method has yet been devised for securing paint films of absolutely the same thickness, but the greatest care was taken in making these films to have them all approximately the same thickness.

Arrangement of Tests

Small bottles, like that shown in the illustration, were half filled with concentrated sulphuric acid and paint films were hermetically sealed over the mouths with Canada balsam. These bottles, numbered, were then accurately weighed on delicate chemical balances and afterward exposed under a large bell jar, all at the same time. This bell jar was so fixed that it could be saturated with moisture and kept under constant temperature. At the end of a week the bottles were removed and carefully weighed again. The increase in weight indicated the amount of moisture which had pen-

etrated the film in each case and which was taken up by the sulphuric acid, by absorption.



Results of Moisture Absorption Tests

The test was kept up for forty-nine days, making weighings every seven days. The figures in the table indicate the amount, in grams, of moisture taken up. The pigments

"MOISTURE EXPERIMENTS"

FIGURES GIVEN EXPRESS GAIN IN WEIGHT, *e. g.*, WATER ABSORBED

	7 days	14 days	21 days	28 days	35 days	49 days
Iron Oxides (with 2% Zinc Chromate and 2% Chrome Resinate)	0.032	0.048	0.072	0.092	0.110	.140
Dutch White Lead	0.040	0.078	0.111	0.162	0.187	.264
White Lead and Zinc Oxide	0.043	0.081	0.115	0.163	0.192	.266
China Clay	0.044	0.086	0.122	0.182	0.219	.317
Whiting	0.044	0.079	0.114	0.167	0.197	.277
Zinc Oxide, Barytes and Blanc Fixe	0.048	0.092	0.125	0.183	0.190	.290
Zinc Lead White	0.049	0.095	0.130	0.181	0.211	.284
Red Lead	0.049	0.092	0.130	0.187	0.215	.295
Basic Sulphate-White Lead	0.049	0.092	0.128	0.185	0.213	.292
Zinc Oxide and Whiting	0.060	0.110	0.156	0.221	0.256	.352
Zinc Chromate	0.064	0.121	0.176	0.270	0.298	.417
Barytes and Zinc Oxide	0.064	0.118	0.169	0.240	0.278	.386
Zinc Oxide	0.065	0.122	0.172	0.244	0.285	.391
Calcium Sulphate	0.066	0.140	0.212	0.313	0.377	.555
American Vermilion	0.069	0.140	0.202	0.311	0.349	.501
White Lead, Barytes and Blanc Fixe	0.074	0.137	0.200	0.294	0.344	.490
Barytes	0.074	0.138	0.202	0.298	0.336	.466
Willow Charcoal	0.077	0.154	0.236	0.378	0.459	.694
Lithopone	0.083	0.156	0.228	0.332	0.380	.550
Carbon Black	0.084	0.168	0.250	0.391	0.448	.654
Lead and Zinc Chromate	0.086	0.161	0.226	0.319	0.369	.497
Chinese Blue Stimulative	0.092	0.185	0.276	0.405	0.470	.671
Venetian Red	0.093	0.190	0.279	0.418	0.508	.770
Natural Graphite	0.104	0.223	0.350	0.539	0.632	.951
Medium Chrome Yellow	0.106	0.207	0.300	0.429	0.505	.725
Bright Red Oxide	0.116	0.240	0.365	0.548	0.662	.976
Barium and Zinc Chromate	0.116	0.211	0.298	0.430	0.481	.660
Ultramarine	0.119	0.230	0.336	0.484	0.578	.814
Prussian Blue Inhibitive	0.125	0.246	0.361	0.521	0.619	.733
Raw Linseed Oil	0.143	0.300	0.449	0.679	0.803	1.201
Lampblack	0.199	0.411	0.641	1.033	1.234	1.873
Blanc Fixe	0.210	0.472	0.744	1.144	1.414	1.944

Carried out by H. A. Gardner and Zoltan de Horvath

have been arranged with regard to the most perfect excluders at the top, followed by those which are less efficient as excluders. As will be noted in the table, the tests all the way through were confirmed at each weighing. At the head of the list stands iron oxide, which contains chromium resinate in small proportion. It will be found by careful observation of the list of pigments in the table that iron oxide by itself falls near the middle, but by the addition of 2 per cent. of chromium resinate, which acts as a gum to seal up the interstices of the pigment, this pigment has been rendered the most excellent water excluder that we have.

Practical, as well as laboratory, tests have brought out the new information which is presented to you, and a study of the tables contained in this book will doubtless prove of value to all interested in paints for the protection of iron and steel.

SUPPLEMENT

The steel wire fences erected in Pittsburg, under the direction of Dr. Cushman, and painted by the Scientific Section, are showing some interesting results. The cut shows a section of wire painted with a stimulative carbonaceous paint. The marked corrosion going on seems to indicate that the most inhibitive paints only should be used for painting iron and steel.

A further description of the steel wire panels may be found in Bulletin No. 35, by Dr. Cushman, of the Office of Public Roads, U. S. Dept. of Agriculture.

Section of wire painted with a stimulative carbonaceons paint